

Amazonian Chironomidae (Diptera, Chironomidae): A contribution to chironomid research in the Neotropics

by

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Abstract

FABRICIUS described the first two South American Chironomidae in 1805, without naming where they were found. A few years earlier, in 1803, MEIGEN had established the first two genera of today's Diptera family Chironomidae, *Tanypus* and *Chironomus*. One hundred years were to go by before Emilio GOELDI discovered the first Chironomidae in the Amazon region and described two species in all their phases of development. Real chironomid research in Brazil, and in particular in Amazonia, did not start until 50 years later. The most comprehensive collection of Amazonian Chironomidae until now was presented at the beginning of the 60s and 70s by the Instituto Nacional de Pesquisas da Amazônia in cooperation with the Max-Planck-Institute for Limnology, Plön. This collection is now in the State Zoological Collection in Munich. At present, approximately 650 existing species are known from Central and South America. Only a third of these, 190 species, from tropical South America have been described, the majority using material from the Munich collection. How inadequate our knowledge still is concerning Amazonian Chironomidae is proven by studies of pupal exuviae from the surface drift of a woodland stream in Central Amazonia, which can be assigned to at least 200 chironomid species. We can expect a total far exceeding 1000 chironomid species in Amazonia alone, the occurrence of which appears to be limited to the Neotropics or which belong to endemic South American genera. Information on dispersal patterns for the individual species or their ecological integration in Amazonian waterways is inadequate at present.

Keywords: Chironomidae, Diptera, Amazonia, Neotropis.

Resumo

FABRICIUS descreveu os primeiros dois Chironomidae da América do Sul em 1805, sem dizer o local da coleta. Alguns anos antes, em 1803, MEIGEN definiu os dois primeiros gêneros de dípteros da família Chironomidae, *Tanypus* e *Chironomus*. Cem anos se passaram antes de que Emilio GOELDI descobrisse os primeiros Chironomidae na região amazônica, descrevendo todas as fases de desenvolvimento para duas

*Dedicated to Prof. Dr. Harald Sioli on the occasion of his 90th anniversary.

espécies. A verdadeira pesquisa relacionada a Chironomidae no Brasil, particularmente na Amazônia, apenas começou 50 anos mais tarde. A mais completa coleção de Chironomidae amazônicos conhecida até hoje foi apresentada no início das décadas 60 e 70 pelo Instituto Nacional de Pesquisas da Amazônia em cooperação com o Instituto Max-Planck para Limnologia em Plön. Esta coleção se encontra agora na Coleção Zoológica Estadual de Munique. No presente aproximadamente 650 espécies são conhecidas na América Central e América do Sul. Apenas um terço delas, 190 espécies, da América do Sul tropical, foram descritas, a maioria com base no material da coleção de Munique. A dimensão da escassez do nosso conhecimento no que se refere aos Chironomidae amazônicos é comprovada por estudos de exúvias de pupas da superfície móvel de um igarapé florestal, que consta no mínimo 200 espécies. Podemos esperar um total de mais de 1000 espécies de Chironimidae apenas na área da Amazônia, cuja ocorrência provavelmente está limitada aos Neotrópicos ou ao gêneros endêmicos da América do Sul. Informações sobre os meios de dispersão para as diferentes espécies e a integração ecológica das espécies às vias aquáticas da Amazônia são ainda inadequadas.

In his study, "Attempt at a new species classification of European two-winged insects" in 1803, MEIGEN established the two genera *Chironomus* and *Tanytus* and so initiated chironomid research. LINNÉ had already known some chironomid species half a century earlier, but he assigned them to *Tipula* genus. It was only two years after MEIGEN's fundamentally important work that, in 1805, his fellow German, FABRICIUS, described *Chironomus maculatus* and *Tanytus pubicornus* from South America, although without stating exactly where they had been found. Further chironomid species from the Neotropics were discovered during the next 100 years, although in terms of worldwide numbers, they remained few. In 1902 KERTÉSZ listed 628 species throughout the world in his "Catalogus dipterorum hucusque descriptorum", 51 of which were of South and Central America. It is notable that the localities where nearly all the species mentioned were found was in the south of the subcontinent in Chile, Argentina and Uruguay, or in Central America. There was no reliable evidence at this time of any representatives of this diptera family, which exists in all waters, from the tropical areas of South America. Apparently during their many years travelling and collecting species in the Amazon region neither BATES nor WALLACE were interested in these insects, which are usually very small and fragile but nevertheless quite obvious in the Tropics.

During the first half of the 20th century research on Neotropical Chironomidae continued to concentrate on species collected in the Andean-Patagonian region or in Central America. There is one exception. In the appendix of his great study of the mosquitoes of Pará which Emílio GOELDI published in 1905, he described the first two Amazonian chironomid species, *Chironomus calligraphus* and *Chironomus holoprasinus*. This publication deserves to be mentioned in particular because for the first time in South America not only were the adult animals described and illustrated in detail but also the eggs, larvae, pupae and the habitat of both species. The descriptions are so good that 50 years later it was possible to find and breed the animals again at the locus typicus in the Museo Goeldi. However, it was shown that GOELDI had made a mistake in his publication in allocating the immature stages to the adult phases. GOELDI had named what is now *Goeldichironomus holoprasinus*, *Chironomus calligraphus*, because of its characteristic spawn (FITTKAU 1965).

The South American species described before GOELDI are in general a serious problem for more recent chironomid taxonomy. As a rule there is neither adequate description of them nor exact information on where they were found or voucher material. Most of them have since to be declared to be nomina nuda as invalid or unplaced

valid species (SPIES & REISS 1996). The fact that these aquatic insects in the tropical regions of South America were overlooked for such a long time proved to be a certain advantage, once chironomid research finally started here. Those involved here in the Neotropics are not concerned with the comparatively difficult taxonomical clarification of "old" species as in Europe. The current problem for chironomidologists is the abundance of "new" species.

Ecological chironomid research in the Amazon region began in the 1940s with water studies undertaken by H. SIOLI and R. BRAUN. They were restricted to qualitative and quantitative larvae collecting in various waters, in particular in the region of the lower Amazon. Information on these studies can be found in the publications of R. BRAUN (1952) and H. SIOLI (1969, 1970), among others. F. LENZ in Plön received the larvae which had been collected for further processing. He published nothing on this matter. The material, partly dissected, is now housed at the State Zoological Collection in Munich. G. MARLIER (1965) carried out the first limnological studies at lakes in the Várzea of the Amazon/Solimões near Manaus, whereby benthos samples were also evaluated.

It should be mentioned here in addition that, after GOELDI, the first chironomid breeding in Brazil and probably in the whole of South America was undertaken by F. LENZ and H. SIOLI in 1934/35 when they investigated reservoirs in north-east Brazil on behalf of the Brazilian government in the framework of the "Comissão Técnica de Piscicultura" (SIOLI 1972). The reared adult stages were described by REMPEL in 1939 and EDWARDS, also 1939. LENZ himself published only the larval and pupal stages of *Coeotanytus tibialis* (LENZ 1939) and the complete metamorphosis of *Pelopia marginata* (LENZ 1950), renamed *Tanytus lenzi* SPIES & REISS 1996. Some of these species from north-east Brazil are now known also from, among other places, the Amazonian region.

The beginnings of independent Brazilian chironomid research go back to the year 1944. At that time Sebastião José de OLIVEIRA, Rio de Janeiro, published his first work on Chironomidae and he has produced many more until today. They deal in particular with Brazilian chironomid fauna outside the Amazonian region in the area of the Atlantic Coast mountain range and the marine species of the coast itself (OLIVEIRA 1995; MESSIAS 2000). His description of his first new Amazonian species and genus, *Lopescladius minutissimus*, appeared in 1967. Recently he and his students have included the fauna of Amazonia in their studies.

Taxonomical analysis of Amazonian chironomid fauna started 50 years after GOELDI. In 1955, Selvin ROBACK, an employee of the Natural History Museum of Philadelphia, was the first person to collect Chironomidae in the catchment area of the Amazon in Peru on the Rio Huallaga near Tingo Maria and on the upper Solimões near Iquitos. From there he described 14 species (ROBACK 1958, 1960) of which 12 were new. In a further study (ROBACK 1966) he published descriptions of larvae and pupae from these localities. At this time ROBACK was the most active chironomid researcher in the USA. He subsequently described other Neotropical species, but not from Amazonia.

I had the opportunity to collect Chironomidae in Amazonia from 1960 to 1963 and in 1965. During the first three years, while I was on leave from the Max-Planck-Institute for Limnology in Plön, I was the head of the Limnology Department in the Instituto Nacional de Pesquisas da Amazônia, INPA, the position held by H. SIOLI before he became director of the Plön Institute in 1958. In 1965 I returned to Manaus

for half a year in order to set up a branch of the Plön Institute at INPA. During my first stay in Manaus the conditions for laboratory work were so bad that I decided to concentrate on studying smaller flowing waterways, their chemistry and colonization (FITTKAU 1964, 1971b). During numerous journeys into the interior of Amazonia I was able, on more than 200 evenings at various localities, to make light catches using a Petromax and a linen cloth and, at more than double the number of localities, to collect pupal exuviae from the surface drift or the Kinal using Brundin nets. As far as possible I also tried to breed larvae at the same time from the benthos samples. Following my first stay, collections were made from waterways in the foreland of the Andes in Peru. In this way it was possible for me to include other additional documentary material from the western peripheral area.

After returning from Brazil I was able, continuing the tradition of August THIENEMANN, to set up a chironomid research centre, with the support of Friedrich REISS after 1967. During the first years the work focused on examining the chironomid material from Amazonia. In order to obtain an impression of the fauna there I examined and processed a few of the light catches having chosen them on the basis of bio-geographical criteria. From the species or groups of species which could be differentiated under a stereo microscope, series were preserved in Canada balsam, later in Euparal, then sketched under the microscope using a drawing mirror and then provisionally defined taxonomically. The numbers of "new species" and "new genera" increased with each new light catch. I stopped this work when we had reached the number of 500 new species and 50 new genera, as well as a number of familiar genera. It had provided us with impressive initial information about the composition of the Amazonian and also tropical South American fauna. We had already gained an impression of the great number of species in Manaus when processing a single surface drift sample. It came from the Igarapé Barro Branco, a small stream in the Reserva Ducke near the town of Manaus. After the necessary preservation, it was possible to distinguish nearly 200 kinds of pupal exuviae and it became clear that the Amazonian region has its own independent rich chironomid fauna (FITTKAU 1971a).

There was no chance of any taxonomical analysis of the material collected within the short term, even with the help of international expert colleagues, because of the amount of time that experience had taught us was required for a thorough description of even one single chironomid species or genus. In addition, it was impossible for both F. REISS and myself to concentrate solely on new descriptions of Chironomidae from the Neotropics as long as there were so many taxonomical problems weighing on chironomid research in general.

In 1971, F. REISS went to Manaus and undertook quantitative and qualitative studies of the chironomid colonization of the benthos in the Várzea and the Igapó lakes near Manaus and of waterways in the savannahs of Roraima. REISS presented the first professional ecological studies of this kind from Amazonia, if we disregard the quantitative larvae investigations which W. JUNK (JUNK 1973; JUNK & ROBERTSON 1997) carried out in his studies on the floating meadows of the Várzea of the lower Solimões (REISS 1976a, 1976b, 1977a, 1977b). At the same time U. IRMLER was recording the aquatic soil fauna, among them the Chironomidae of the flood forests of Central Amazonia (IRMLER 1975). Later, U. NOLTE carried out additional studies on the colonization of the floating meadows of the Várzea, in which the Chironomidae were given particular attention (NOLTE 1988).

The first new genus from Amazonia, *Manoa*, was presented at the second Brazilian Zoological Congress in Porto Alegre in 1961 (FITTKAU 1963). All the efforts which the director of INPA made at that time to attract an entomologically interested biologist to Manaus to support my work were just as unsuccessful as my later attempts to find a Brazilian who would be prepared to work in chironomid studies in Plön. The latter wish was fulfilled only 30 years later after I had retired. However, Sebastião de OLIVEIRA would have been delighted to take up a research grant arranged for him at the Max-Planck-Institute for Limnology. Unfortunately, for political reasons it was to be another 30 years before he would be able to accept such an invitation, this time to go to Munich.

In 1976 I left the Max-Planck-Institute in Plön and became head of the State Zoological Collection in Munich, one of the 10 largest zoological museums in the world, which first began in 1810 under Johann Baptist von SPIX, before he had started his "Journeys in Brazil" together with Conrad Friedrich von MARTIUS (FITTKAU 1983, 1992). In leaving I saw the opportunity of including the Plön chironomid centre in a museum where there would be better chances of continuity than in a modern ecological research institute. The head of the Max-Planck-Institute was laudable in accepting my ideas and allowed me to take my collection, the collections of F. LENZ and A. THIENEMANN and also THIENEMANN's chironomid library to Munich. I was also able to place F. REISS in the position of curator of the State Collection in order to work further with the new chironomid centre which was now to be set up in Munich (REISS 1992).

During the following years it was possible to catch up partially with the work on the Amazonian chironomid collection. F. REISS saw it as his particular task, as well as publishing his own studies, to work further on the collection material and welcomed any form of international assistance. Two doctoral dissertations in the USA were based to a large extent on material that had originally been preserved in Plön: A. BORKENT's (1984) monographic treatment of the genus *Stenochironomus* and J.H. EPLER's study (1988) of *Dicrotendipes*. As a member of the Biology Faculty at the Ludwig Maximilian University in Munich I am still to this day supervisor for doctoral theses which make use of the Amazonian chironomid material in the collection: N. BIDAVID worked on imagines of the genus *Polypedilum* (BIDAVID 1985; BIDAVID et al. 1996; BIDAVID-KAFKA 1996), A. SCHNEIDEBERG on the pupal exuviae of tanypodines from the surface drift of various flowing waters (1985), R. Ospina TORRES, scholarship holder of the German Academic Exchange Service (DAAD) from Columbia, analysed several surface drift catches from streams in the surroundings of Manaus (1992). M. SPIES described the South American species of the genus *Parachironomus* (1994). As a scholarship holder of the Alexander von Humboldt Foundation, L. SÄVEDAHL studied the new genus *Caladomyia* (1981) and new species of the genus *Stempellinella* (1984), and A. R. SOPONIS investigated both new genera *Paranilothauna* and *Nee-lamia* (1987). A further contribution in which material from Amazonia collection was used was supplied by J.H. EPLER, among others, with a description of the new genus *Oukuriella* (1986), by N. REIFF with a review of the genus *Caladomyia* (2000) and by O. SAETHER with a review of the genus *Lopescladius* (1983).

In recent years it has been possible with the help of grants from the DAAD for three students from Brazil and one from Germany to study the taxonomy of Chironomidae in Munich. Maria Conceição MESSIAS gained her doctorate in Rio de Janeiro with a review of the genus *Oukuriella* (1998) after she had worked in Munich for two years.

Lisa STUR carried out an inventory of the larval colonization of the upper course of a small tributary of the Rio Cuiabá, which flows into the Pantanal (STUR 2000). Sofia WIEDENBRUG presented a thesis on chironomid pupal exuviae from the surface drift of rivulets in Rio Grande do Sul (2000) for her doctorate. The evaluation of her results was not only useful for an inventory of Chironomidae in rivulets near Manaus, published by OSPINA (1992), but also another Munich dissertation from B. STUMPP (1993) in which chironomid pupal exuviae from the surface drift of flowing waters in the area of Rio de Janeiro were described. For the last two years a further DAAD scholarship holder, Angela SANSEVERINO, has been working on a taxonomical doctoral thesis at the State Collection on a genus complex of the Tanytarsini, one of the most species-diverse groups in Amazonia. All the candidates have produced various taxonomical publications while working on their doctoral theses (MESSIAS 2000; MESSIAS et al. 1997, 2000; SANSEVERINO et al. 2000, STUR et al. 1997, 2000; WIEDENBRUG et al. 1997, 1998). They made their own contributions to the 14th International Symposium on Chironomidae, which was held in South America for the first time in 2000 in Rio de Janeiro. It became clear there that chironomid research in the Neotropics has a very promising future.

The present state of taxonomical chironomid research in South and Central America is reflected in the "Catalogue and bibliography of Neotropical and Mexican Chironomidae", SPIES & REISS (1996). Here 709 valid described species in 155 genera are given for South America. Of these, 102 species names and 5 genus names should be seen as "nomina dubiae" or "invalid names" in accordance with the rules of international nomenclature. Since the catalogue was published, the number of nominal species has increased to 758 and the genera to 170 (M. SPIES, pers. comm.). Of the additional species, 41 are new descriptions, the others are species where there is now proof that they exist in the Neotropics. Only three of the 25 additional species are new taxa. Of the 650 species which can presently be said to exist in South and Central America, there is evidence of 190 species, i.e. less than a third, in Brazil. The majority of Neotropical species continue to be described from the Andean-Patagonian region and from Central America. Of the "Brazilian" species, 165 have been found in Amazonia and come, with few exceptions, from the Plön/Munich collection. This number of species shows all too clearly just how much remains to be done in researching chironomid fauna in tropical South America, in spite of all the efforts that have already been made. As has already been mentioned, we know from the analysis of our surface drift catches that there are more than 200 chironomid species in one small primary forest rivulet in Central Amazonia. More than 500 new species, some of them representative of new, undescribed genera, are to be found in the State Zoological Collection, taxonomically documented in the pupal stage as morphotypes or as adults, prepared as microscopic slides. We do not know how many species in the collection have not yet been recorded. Based on our knowledge of the data from analysing light catches and the processing of special groups which has already been completed, it is likely that there are very many. It can be assumed that the number of Chironomidae to be found in Amazonia alone greatly exceeds 1,000 species.

As long as knowledge of Neotropical, in particular Amazonian chironomid fauna is still so incomplete, it is possible to give only very sketchy information on the dispersion patterns of the numerous Amazonian species and genera, which have until now been seen as endemic. It has become clear that Amazonian chironomid fauna, even at genus

level, has little in common with the fauna of the Andean-Patagonian region, which is better known in comparison. At the species level this difference already exists in southern Brazil, as the proven spectrum of exuviae morphotypes from the streams of the Rio Grande do Sul shows (WIEDENBRUG 2000). However, transantarctic fauna elements – the genera *Fissimentum*, *Nandeva*, and *Rietha* – have been found here which occur more frequently in the Andean-Patagonian bio-geographical region (BRUNDIN 1966).

Apparently the Chironomidae in South America have developed independently since the continent broke free of Gondwana. In the case of the "great genera" *Tanytarsus* and *Polypedilum* there are greater similarities in the formation of characteristics between the African and the Holarctic species than between the Nearctic and the Neotropical. Species similarity between North and South American species seems to be the exception. It is possible to see a limited exchange of fauna between North and South America, via Central America, above all in the Andean region, but it seems that this hardly reached Amazonia. At the moment it is impossible to say to what extent not only new species but also new genera have developed since the interruption of fauna exchange between South America and Africa. Tropical African fauna is not yet well known enough. In addition, it can be assumed that common development lines in Africa will only partly have survived the extremely dry Later Tertiary and Pleistocene periods. Recently, a second species of the genus *Manoa*, which had been found previously only in the area of Manaus, was discovered in Tanzania, Africa (ANDERSEN et al. 1997). The habitat of the Amazonian species is instable shallow water areas of a spring on terra firma. The Tanypodine *Djalmabatista* which exists in South America in many kinds of species, seemed to be a typical "South American" until I found exuviae of one species of this genus in a small Chinese stream on the border to Laos. In the meantime, this genus has also been found in Ghana, Africa (SAETHER et al. 2000). The Tanypodine genus *Fittkauimyia* was first described from Malaysia, in the meantime it has been discovered in Africa and Mato Grosso, Brazil (SERRANO et al. 1996). The discovery of a new genus, *Fissimentum*, a second species of which is known in Australia, in the south of Brazil was equally unexpected (CRANSTON et al. 1996; CRANSTON 1999). Maybe this genus represents an element of an old fauna, common in the transantarctic and adapted to heat.

Statements on the ecological integration of chironomid species in the waterway systems of Amazonia are possible only in a few cases at present. Our taxonomical knowledge of the species of the Neotropics does not extend further, in general, than the pupae and imaginal stages. The assignment of larvae ends at the genus level, even in case of extremely critical analysis of qualitative or quantitative collections, as was shown in a water investigation in Mato Grosso (STUR 2000). Such investigations, which are also carried out in Amazonia (NESSIMIAN et al. 1998; WALKER 1998) can contribute to our understanding of the function and structure of aquatic ecosystems without a taxonomical analysis to species or genus level. It is regrettable that Chironomidae must now be included in Amazonia as indicator organisms for water pollution before the chironomid fauna there is known (CALLISTO et al. 1998; FONSECA et al. 1998).

Chironomid research in Amazonia region, in the whole of the Neotropics, should concentrate intensively first of all on recording taxonomically the diversity of species. If possible all developmental stages should be included. Work of this kind can only be

carried out on the spot and with international cooperation. The State Zoological Collection has already made such initiatives. There was a successful cooperation with the Zoological Institute of the University of Cuiabá which led to the inclusion of aquatic insects in the taxonomical and ecological research which was carried out in the field (SERRANO et al. 1998). Since 1998 there has been close cooperation with scientists from the Entomological Collection of the Instituto Oswaldo Cruz in Rio de Janeiro. The International Chironomid Symposium held there was a result of this cooperation. It represented international recognition for the attempts to do justice to South American and thus also to Amazonian chironomid research.

References

- ANDERSEN, T. & O.A. SAETHER (1997): First record of *Manoa* FITTKAU and tribe Pseudochironomini SAETHER from the Afrotropical region (Diptera: Chironomidae: Chironominae). - Ent. Scand. **28**: 311-317.
- BIDAWID, N. (1985): Zur Kenntnis der neotropischen Arten der Gattung *Polipedium* KIEFFER (Chironomidae: Diptera, Chironomidae). Systematik, Ökologie und Verbreitung. - PhD-thesis, Ludwig-Maximilians-Univ. München: 281 pp.
- BIDAWID, N. & E.J. FITTKAU (1996): Zur Kenntnis der neotropischen Arten der Gattung *Polypedium* KIEFFER, 1912. Teil I (Diptera, Chironomidae). - Entomofauna **16**: 465-536.
- BIDAWID-KAFKA, N. (1996): Zur Kenntnis der neotropischen Arten der Gattung *Polypedium* KIEFFER, 1912. Teil II (Diptera, Chironomidae). - Entomofauna **17**: 165-240.
- BORKENT, A. (1984): The systematics and phylogeny of the *Stenochironomus* complex (*Xestochironomus*, *Harrisius*, and *Stenochironomus*) (Diptera: Chironomidae). - Mem. Entomol. Soc. Can. **128**: 1-269.
- BRAUN, R. (1952): Limnologische Untersuchungen an einigen Seen im Amazonasgebiet. - Schweiz. Z. Hydrol. **14**: 1-128.
- BRUNDIN, L. (1966): Transantarctic relationships and their significance as evidenced by chironomid midges. With a monograph of the subfamilies Podonominae and Aphroteniinae and the austral Heptagyidae. - Kungl. Svenska Vetenskapsakad. Handl. **11**: 1-472.
- CALLISTO, M., ESTEVES, F.A., FONSECA, J.J. & J.F. GONÇALVES JR. (1998): Benthic macroinvertebrates of four Amazonian streams influenced by bauxite mining (Brasil). - Verh. Int. Ver. Limnol. **26**: 983-985.
- CRANSTON, P.S. (1999): Two unusual Chironomini (Diptera: Chironomidae) from Australian rainforest streams: one new genus and a Neotropical new for the region. - Austral. J. Ent. **3**: 37-47.
- CRANSTON, P.A. & U. NOLTE (1996): *Fissimentum*, a new genus of drought-tolerant Chironomini (Diptera: Chironomidae) from the Americas and Australia. - Ent. News **107**: 1-15.
- FONSECA, J.J., CALLISTO, M.F.P. & J.F. GONÇALVES JR. (1998): Benthic macroinvertebrate community structure in an Amazonian lake impacted by bauxite tailings (Pará, Brasil). - Verh. Int. Ver. Limnol. **26**: 2053-2055.
- EDWARDS, F.W. (1939): In: LENZ, F. (1939). Die Chironomidengattung *Coelotanypus* (mit einem Beitrag von F.W. EDWARDS, London). - Zool. Anz. **127**: 177-184.
- EPLER, J.H. (1986): *Oukuriella*, a new genus of Chironomidae (Diptera) from South America. - Entomol. Scand. **17**: 157-163.
- EPLER, J.H. (1988): Biosystematics of the genus *Dicrotendipes* KIEFFER, 1913 (Diptera: Chironomidae: Chironominae) of the world. - Mem. Am. Entomol. Soc. **36**: 1-214.
- FITTKAU, E.J. (1963): *Manoa*, eine neue Gattung der Chironomidae (Diptera) aus Zentralamazonien. (Chironomidenstudien IX). - Arch. Hydrobiol. **59**: 373-390.

- FITTKAU, E.J. (1964): Remarks on Limnology of Central-Amazonian Rain Forest Streams. - Verh. Int. Ver. Limnol. **15**: 1092-1096.
- FITTKAU, E.J. (1965): Revision der von E. GOELDI in aus dem Amazonasgebiet beschriebenen Chironomiden (Diptera). (Chironomidenstudien X). - Beitr. neotrop. Fauna **4**: 209-226.
- FITTKAU, E.J. (1971a): Distribution and ecology of Amazonien Chironomids (Diptera). - Can. Ent. **103**: 407-413.
- FITTKAU, E.J. (1971b): Ökologische Gliederung des Amazonasgebietes auf geochemischer Grundlage. - Münster. Forsch. Geol. Paläont. **20/21**: 35-50.
- FITTKAU, E.J. (1983): Johann Baptist Ritter von SPIX. Sein Leben und sein wissenschaftliches Werk. - Spixiana, Suppl. **9**: 201-218.
- FITTKAU, E.J. (1992): Vom Naturalienkabinett zum modernen Forschungsinstitut: Geschichte und Bedeutung der Zoologischen Staatssammlung. - Spixiana, Suppl. **17**: 24-34.
- GOELDI, E.A. (1905): Os mosquitos no Pará. - Mem. Mus. Paraense. Hist. Nat. Ethnogr. **4**: 134-139.
- IRMLER, U. (1975): Ecological studies of the aquatic soil invertebrates in three inundation forests of Central Amazonia. - Amazoniana **5**: 339-406.
- JUNK, W.J. (1973): Investigations on the ecology and production-biology of the "floating meadows" (Paspalo-Echinochloetum) on the middle Amazon. Part II. The aquatic fauna in the root zone of floating vegetation. - Amazoniana **4**: 9-102.
- JUNK, W.J. & B.A. ROBERTSON (1997): Aquatic invertebrates: 279-298. In: JUNK, W.J. (ed.): The Central Amazon floodplain. Ecology of a pulsing system. - Ecol. Stud. **126**. Springer, Berlin: 525 pp.
- KERTÉSZ, K. (1902): Catalogus dipterorum hucusque descriptorum. Vol. I. - Engelmann, Leipzig + Mus. Nat. Hungar., Budapest: 396 pp.
- LENZ, F. (1939): Die Chironomidengattung *Coelotanypus* (mit einem Beitrag von F.W. EDWARDS, London). - Zool. Anz. **127**: 177-184.
- LENZ, F. (1950): Die Metamorphose einer tropischen *Pelopia*-Art. - Zool. Anz. **145**: 502-515.
- MARLIER, G. (1965): Etude sur les lacs de l'Amazonie Centrale. - Cadernos da Amazônia **5**: 1-52.
- MESSIAS, M.C. (2000): Sebastião José de OLIVEIRA, uma vida dedicada ao Instituto Oswaldo Cruz. - Entomologia y Vectores (Rio de Janeiro) **7**: 239-233.
- MESSIAS, M.C. & E.J. FITTKAU (1997): Two new species of the Neotropical genus *Oukuriella* EPLER, 1986 (Insecta, Diptera, Chironomidae). - Spixiana **23**: 159-161.
- MESSIAS, M.C., FITTKAU, E.J. & S.J. OLIVEIRA (2000): A new species of *Oukuriella* EPLER (Diptera, Chironomidae, Chironominae) with the first descriptions of immature stages for the genus: 183-188. In: HOFFRICHTER, O. (ed.): Late 20th century research on Chironomidae. An anthology from the 13th Int. Symp. on Chironomidae. - Shaker Verlag, Aachen: 661 pp.
- MESSIAS, M.C. & S.J. OLIVEIRA (1999): On a new species of the genus *Oukuriella* EPLER (Diptera, Chironomidae, Chironominae). - J. Kansas Ent. Soc. **71**: 260-262.
- NESSIMIAN, J., DORVILLE, L.F.M., SANSEVERINO, A.M. & D.F. BAPTISTA (1998): Relation between flood pulse and functional composition of the fauna in the lower Rio Negro, Amazonas, Brasil. - Amazoniana **15**: 35-50.
- NOLTE, U. (1988): Small water colonisation in pulse stable (várzea) and constant (terra firme) biotops in the Neotropics. - Arch. Hydrobiol. **113**: 541-550.
- OLIVEIRA, S.J. (1944): Sobre a presença de "*Tanypus stellatus*" COQUILLETTE, 1902 no estado de Minas Gerais, Brasil (Diptera, Chironomidae, Tanypodinae). - Rev. Bras. Biol. **4**: 91-94.
- OLIVEIRA, S.J. (1967): Novo gênero de Chironomidae da Amazônia (Insecta, Diptera). - Atas Simpósio Biota Amazônica (Zool.) **5**: 417-419.
- OLIVEIRA, S.J. (1995): The history of research on Brazilian Chironomidae. - Chironomus Newsletter **7**: 9-10.
- OSPINA TORRES, R. (1992): Die Chironomidenfauna zentral-amazonischer Waldbäche. - PhD-thesis Ludwig-Maximilians-Univ. München: 357 pp.
- REIFF, N. (2000): Review of the mainly Neotropical genus *Caladomyia* SÄVEDAL, 1981, with descriptions of seven new species (Insecta, Diptera, Chironomidae, Tanytarsini). - Spixiana **23**: 175-198.

REISS, F. (1976a): Charakterisierung zentralamazonischer Seen aufgrund ihrer Macrobenthosfauna. - *Amazoniana* **6**: 123-143.

REISS, F. (1976b): Die Benthoszooenosen zentralamazonischer Várzeeseen und ihre Anpassungen an die jahresperiodischen Wasserstandsschwankungen. - *Biogeographica* **7**: 125-135.

REISS, F. (1977a): Qualitative and quantitative investigations on the macrobenthic fauna of Central Amazon lakes. Lago Tupé, a black water lake on the lower Rio Negro. - *Amazoniana* **6**: 203-235.

REISS, F. (1977b): The benthic zooenoses of Central Amazon Várzea lakes and their adaptations to the annual water level fluctuations. - *Geo-Eco-Trop.* **1**: 65-75.

REISS, F. (1992): Die Sektion Diptera der Zoologischen Staatssammlung München. - *Spixiana* Suppl. **17**: 72-82.

REMPEL, J.G. (1939): Neue Chironomiden aus Nordostbrasilien. - *Zool. Anz.* **127**: 209-216.

ROBACK, S.S. (1958): Results of the Catherwood Foundation Peruvian Amazon Expedition. A new genus and species of Tendipedini from Peru with some observations on related genera. Diptera, Tendipedidae (= Chironomidae). - *Notulae Nat.* **304**: 1-5.

ROBACK, S.S. (1960): Results of the Catherwood Foundation Peruvian Amazon Expedition. New species of Tendipedidae (Diptera). - *Trans. Am. Entomol. Soc.* **86**: 87-107.

ROBACK, S.S. (1966): The Catherwood Foundation Peruvian Amazon Expedition. XII. Diptera, with some observations on the salivary glands of the Tendipedidae. - *Monogr. Acad. Nat. Sci. Philadelphia* **14**: 305-375.

SAETHER, O.A. (1983): Three new species of *Lopescladius*, OLIVEIRA, 1967 (syn. "*Corditis*" BRUNDIN, 1966, n. syn.), with a phylogeny of the *Parakiefferiella* group. - *Mem. Am. Entomol. Soc.* **34**: 279-298.

SAETHER, O.A. & T. ANDERSEN (2000): *Djalmabatista reidi* (FREEMAN) comb. n. and *Lepidopeloplia annulator* (GOETHGEBUER), two interesting macropelopine tanypods from Ghana (Diptera: Chironomidae): 209-220. - In: HOFFRICHTER, O. (ed.): Late 20th century research on Chironomidae. An anthology from the 13th Int. Symp. on Chironomidae. - Shaker Verlag, Aachen: 661 pp.

SÄVEDAL, L. (1981): Amazonian Tanytarsini I. *Caladomyia* n. gen. and eight new species (Diptera: Chironomidae). - *Entomol. Scand.* **12**: 123-143.

SÄVEDAL, L. (1984): The *curiurui*-group of the genus *Stempelinella*. Amazonien Tanytarsini II. (Diptera: Chironomidae). - *Entomol. Scand.* **15**: 141-149.

SANSEVERINO, A. & S. WIEDENBRUG (2000): Description of the pupa of *Tanytarsus cuierensis* FITTKAU & REISS (Insecta, Diptera, Chironomidae). - *Spixiana* **23**: 207-210.

SCHNEIDBERG, A. (1985): Studie zur Morphologie, Systematik und Verbreitung neotropischer Tanypodinae (Chironomidae, Diptera). - MSc-thesis, Ludwig-Maximilians-Univ. München: 202 pp.

SERRANO, M.A.S. & U. NOLTE (1996): A sit-and-wait predatory chironomid from tropical Brasil - *Fittkauimyia crypta* sp.n. (Diptera, Chironomidae). - *Ent. scand.* **21**: 251-258.

SERRANO, M.A.S., SEVERI, W. & V.J. TOLEDO (1998): Comunidades de Chironomidae e outros macroinvertebrados em um rio tropical de planície - Rio Bento Gomes/MT. - *Oecol. Bras.* **5**: 265-278.

SIOLI, H. (1969): Ökologie im brasilianischen Amazonasgebiet. Arbeiten der Abteilung Tropenökologie des Max-Planck-Institutes für Limnologie. - *Naturwissenschaften* **56**: 248-255.

SIOLI, H. (1970): Ökologische Untersuchungen im Amazonasgebiet. - *Umschau* **70**: 783-748.

SIOLI, H. (1972): FRIEDRICH LENZ. - *Mitteilungen der Max-Planck-Gesellschaft* **5**: 333-336.

SOPONIS, A.R. (1987): *Paranilothauma* and *Neelamia*, new genera of Chironomini (Diptera: Chironomidae) from Brasil. - *Stud. Neotrop. Fauna & Environm.* **22**: 11-24.

SPIES, M., FITTKAU, E.J. & F. REISS (1994): The adult males of *Parachironomus* LENZ, 1921, from the Neotropical faunal region (Insecta, Diptera, Chironomidae). - *Spixiana*, Suppl. **20**: 61-98.

SPIES, M. & F. REISS (1996): Catalog and bibliography of Neotropical and Mexican Chironomidae. - *Spixiana*, Suppl. **22**: 61-119.

STUMPP, B. (1993): Die Makrozoobenthosfauna südbrasilianischer Fließgewässer unter besonderer Berücksichtigung der Chironomiden und ihre indikative Bedeutung für Abwasserbelastung am Beispiel von Flüssen im Gebiet des Staates Rio de Janeiro. - PhD-thesis, Ludwig-Maximilians-Univ. München: 445 pp.

STUR, E. (2000): Chironomidengemeinschaften (Diptera, Nematocera) des Rio Bento Gomes, eines intermittierenden neotropischen Tieflandflusses. - PhD-thesis, Ludwig-Maximilians-Univ. München: 177 pp.

STUR, E. & E.J. FITTKAU (1997): Diagnostic characters distinguishing the 1 arvae of *Ablabesmyia* and *Paramerina*, and first record of *Paramerina* in Brasil. - *Spixiana* **20**: 161-165.

WALKER, I. (1998): Population dynamics of Chironomidae (Diptera) in the central Amazonien blackwater river Tarumã-Mirim, Amazonas, Brasil. - *Oecol. Bras.* **5**: 235-252.

WIEDENBRUG, S. (2000): Studie zur Chironomidenfauna aus Bergbächen von Rio Grande do Sul, Brasilien. - PhD-thesis, Ludwig-Maximilians-Univ. München: 444 pp.

WIEDENBRUG, S. & E.J. FITTKAU (1997): *Oliveiriella almeidai* (OLIVEIRA, 1946) gen. nov., comb. nov. from South America with description of the pupae (Diptera, Chironomidae, Orthoclaadiinae). - *Spixiana* **20**: 167-172.

WIEDENBRUG, S., REISS, F. & E.J. FITTKAU (1998): *Nandeva*, gen. nov., a new genus of Chironomini (Insecta, Diptera, Chironomidae). - *Spixiana* **21**: 59-68.